Midterm Exam 2 (PY 413, Spring 2007)

1. (10pts) A hydrogen fuel cell is based on the reaction $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$.

   (a) How much electrical energy W_{el} and heat Q are produced if 1 mole of H_2 and 1/2 mole of O_2 are converted to H_2O at room temperature? How much work is done by the atmosphere (assume that the gases are kept at room temperature, and that the volume of liquid water is negligible as compared to the volume of the gases)? Draw a diagram that shows the direction of energy flow (Q, W_{el}, W_{mech}) into and out of the fuel cell.

   (b) The reaction at the anode is $H_2 \rightarrow 2e^- + 2H^+$. What is the voltage of the fuel cell?

   The enthalpy and Gibbs free energy of formation for one mole of liquid water are $\Delta H = -285.83$ kJ and $\Delta G = -237.13$ kJ.

2. (10pts) The vapor pressure equation is $P(T) = P_0 \exp(-L/(RT))$ where P_0 is a constant, L is the latent heat (per mol), and R is the ideal gas constant. The latent heat of water is $L = 4.066 \cdot 10^4$ J/mol.

   (a) Determine the constant P_0 using the boiling temperature of water at atmospheric pressure.

   (b) Determine the amount of water (by weight) contained in 1 liter of air at room temperature (20 ^{o}C) and 100% humidity. You can assume that water vapor is an ideal gas. The atomic weights of oxygen and hydrogen are 16u and 1u, respectively

3. (10pts) Air at sea level is about 80% nitrogen N_2 and 20% Oxygen O_2. Use the Boltzmann distribution to determine the composition at a height of 10km above sea level. The atomic weights of oxygen and nitrogen are 16u and 14u, respectively.

4. (2pts, Bonus problem, no partial credit) An insulated container is divided into two sections of volumes V_1 and V_2 by a partition. The two sections contain N_1 and N_2 atoms of the same ideal gas. Both sections are initially in equilibrium at the temperature T. The partition is then removed and the system comes to equilibrium once more. What is the final temperature of the whole system? What is the change in entropy of the whole system?